

Project Title: Control of Invasive Carp in the Lower Mississippi River Basin**Geographic Location:****1.**

1.1. Mississippi River from the Missouri-Arkansas border (RM 828) to the confluence of the Ohio River (RM 953).

1.2. Lower White River, Lower Arkansas River and their tributaries and oxbow lakes.

1.3. Mississippi River from the Mississippi-Louisiana border (RM 306) to the Mississippi-Tennessee border (RM 715) and the Yazoo River basin within Mississippi.

2. Reelfoot Lake

3. Mississippi River from the Missouri-Arkansas border (RM 828) to the confluence of the Ohio River (RM 953).

Lead Agency:

- Missouri Department of Conservation (MDC), Joe McMullen, joe.mcmullen@mdc.mo.gov

Participating Agencies: Matches proposal and workplans.

- Arkansas Game and Fish Commission (AGFC), Jimmy Barnett, jimmy.barnett@agfc.ar.gov
- Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Dennis Riecke, dennis.riecke@wfp.ms.us
- Tennessee Wildlife Resources Agency (TWRA), Cole Harty, cole.r.harty@tn.gov

Statement of Need: Populations of invasive carp (silver carp, bighead carp, black carp, and grass carp) have rapidly expanded throughout the Mississippi River basin. Management and control of invasive carp is necessary to reduce their impact on native species, the ecosystem, and the economy. In response to these threats, many states throughout the Mississippi and Great Lakes basins have been working to find effective strategies to manage existing populations and to control the expansion of invasive carp into adjacent aquatic systems. Appropriations for the Department of Interior indicate that ‘while the Committees (House Subcommittee on Interior, environment, and Related Agencies and the Senate Subcommittee on Interior, Environment, and Related Agencies) recognize the importance of studying and understanding invasive carp patterns, the Service is encouraged to take action on a strategy that increases the focus on biomass removal and restricts carp progression by coordinating with other Federal partners on constructing invasive carp barriers’. This project addresses the need for biomass removal and

provides the opportunity to collect data on invasive carp populations and native fish communities that may inform future removal efforts.

Project Objectives:

1. Reduce overall invasive carp population numbers and alleviate propagule pressure in areas with low population density by implementing removal programs utilizing agency staff and contract fishing.
2. Reduce the overall density and determine population characteristics of invasive carp.
3. Monitor fish assemblages and determine responses to targeted invasive carp removal efforts.

Project Highlights:

1.
 - 1.1. Contract/commercial removal efforts are still being pursued; however, no removals have been completed by MDC at the time of this report. MDC staff will continue working internally and with interested vendors to pursue removal actions.
 - 1.2. AGFC crews netted for 116 days and a total of 5,178 invasive carp weighing 85,488.8 pounds were captured and removed. Silver carp comprised 92% (4753), bighead carp 4% (192), grass carp 4% (230) and black carp .05% (3) of the total.
 - 1.3. Firms contracting with MDWFP purchased a total of 24,986 pounds of invasive carp during 2022. Silver carp comprised 97% (24,292 lbs.), bighead carp 1.5% (384 lbs.), and grass carp 1.5% (310 lbs.) of the total poundage.
2. As observed in previous years, silver carp collected by TWRA in Reelfoot Lake were relatively large compared to other populations in Tennessee. No silver carp <650mm in length were collected and ages varied from 4 to 13 years old, suggesting the existing population is a result of migration into Reelfoot Lake rather than successful reproduction within it. Removal and bowfishing efforts remain difficult for a variety of reasons, including staff capacity, limited interest, and numerous competing seasonal constraints.
3. Fish assemblage sampling was conducted by MDC at 15 randomly selected sites. A total of 1,453 fish (38 species) were collected.

Methods:

1.
 - 1.1. MDC: None

1.2. Three more part-time technicians “Invasive Carp Removal Specialists” were hired by AGFC and started work on 3 January 2022. Their addition completed our in-house removal program plan to acquire five technicians to operate two boat crews. A full staff for the removal program consist of five extra-labor Carp Removal Specialists and one full-time Invasive Carp Biologist, who supervises the removal crew members.

Various netting techniques and net configurations were used throughout the year to determine what methods and gear worked best to catch invasive carp in Arkansas waters. Initially, 100-yard gill nets were deployed individually in areas were invasive carp (mainly silver carp) were located using side scan sonar. Boats were used to herd invasive carp into the nets. Netting was conducted in an active manner, with nets not left unattended. Each boat crew would set three to twelve gill nets, depending on invasive carp detections. These nets were allowed to soak for 1-4 hours before being retrieved. Data was collected from each net set, including GPS coordinates, date, time in, time out, mesh size, net length, net depth, number and species of invasive carp captured, and other species captured and released. Lengths and weights were collected from a random subsample of invasive carp during each day. Data collected was recorded on paper data sheets in the field, then entered into a database to document removal efforts and inform future management actions.

The removal program used on the water experience to modify methods and gear to improve catch rates. Subsequently, new gill nets were acquired and gear deployment was altered. Capture of invasive carp were most successful when using six 100-yard, 4 ½-inch, red 7-ply or 4 ¼-inch clear 8-ply monofilament webbing. These nets are 12 feet deep, tied down to 10 feet, on foam core float line and lead core lead line with one extra mesh per tie. Nets were attached together to eliminate space between nets and allow for deployment of multiple nets in a single set. Techniques were changed from individual net sets to deployment of a net series (up to six 100-yard nets), which were quickly set around a school of invasive carp, and then spiraling inward. After the nets were deployed, the crews use boat motor noise, boat movement, and loud boat banging to spook the fish and get them to move rapidly, decreasing their net avoidance. This method creates multiple net layers that help capture fish that jump over the net. The boat crew navigates back into the center of the spiral and begins retrieving the nets and captured fish. All invasive carp are removed and euthanized. The body cavity of all silver, black and grass carp were cut open, swim bladder ruptured, and carcasses were disposed of in a nearby main river channel. Bighead carp were brought back and placed in a freezer at the Wattensaw Wildlife Management Area compound and were periodically collected by students from the University of Arkansas at Pine Bluff for collection of biological data. These fish were used to increase sample size of bighead

carp for an ongoing research project *Invasive Carp Movement and Assessment to Inform Management and Removal Efforts in the Lower Mississippi River Basin*.

1.3. MDWFP contracted with two instate invasive carp processing firms to reimburse them \$0.18 per pound if they paid MS commercial fishermen at least \$0.25 per pound for invasive carp harvested from the project area.

2. TWRA staff conducted invasive carp sampling with gill nets during summer (August) and fall (November) of 2022. Sixteen gill netting sites were selected in Reelfoot Lake, which included Keystone Pocket (4 sites), Lower Basin (4 sites), the Spillway (4 sites), and Joe Basin (4 sites). Four nets were deployed during daytime hours at each site during each season and pulled the following morning. Nets were distributed throughout each site at depths less than 12-feet. Individual nets were 300-ft in length with 100-ft panels of 3-, 4-, and 5-inch mesh. Nets were 12-ft deep, hobbled to 10-ft every eight feet; nets had 0.5-inch foamcore for the float line and 65-lb leadcore for the lead line. The webbing used in each panel was constructed of 8 ply, 0.2-mm twist mesh.

Standardized electrofishing was planned for Reelfoot Lake in 2022; however, record low water levels in both summer and fall prevented the completion of this effort. Rather, crew and equipment safety were prioritized due to hazardous under-water structures located throughout Reelfoot Lake.

Total length (mm), weight (kg), and sex were measured and recorded for all invasive carp collected. Because a standardized method for age determination has not been developed and agreed upon by partners, two aging structures were taken from silver carp in 2022. Lapillar otoliths and pectoral fin rays were collected from 10 silver carp per 50mm length group when obtainable during fall gill net sampling. Though not included in the analysis here, we intend to pursue comparisons of age estimates using the two differing structures with the assistance of partners. TWRA staff opted to proceed with the use of pectoral fin rays for age estimation presented in this report due to ease of processing, relative ease of age estimation, and agreement by readers.

The first fin ray below the articulating process was removed on the left side of fish when available. Excess tissue was then cleaned off the fin ray, fin rays were placed in a coin envelope, and envelopes were hung in the laboratory for several weeks to air dry. After drying, fin rays were cut with a low-speed isometric saw. When clamping the fin ray in the chuck, blade alignment was made where the base of the fin ray begins to sharply curve. Once the first cut was complete, the adjustment knob was turned one full rotation and 6 clicks (31 micrometers), and the second cut was performed. Thin sections were dried off and placed back into the coin envelope for future aging.

Contract/commercial removal efforts are still being pursued; however, no removals have been completed at the time of this report. TWRA staff will continue working with interested vendors to pursue removal actions. Reelfoot Lake is a unique resource that presents many complications for standard removal efforts including copious debris/snags, seasonally important fisheries (i.e., spring crappie fishery), abundant vegetation during warmer months, and high-profile duck hunting use. Like contract/commercial removal efforts, bowfishing opportunities are still being pursued by TWRA staff, though no bowfishing events have been conducted at the time of this report. We anticipate holding this type of event in the coming year and plan to collect data from harvested carp.

3. MDC staff conducted fish assemblage sampling during fall 2022 to collect baseline data to identify any potential effects that invasive carp removals may have on native fish. Sites were randomly selected and sampling was standardized with Long Term Resource Monitoring sampling efforts on the upper Mississippi River (Ratcliff et al. 2014). Sampling sites were located within a relatively small section of river due to accessibility issues associated with record low water levels. All fish captured were identified and measured, and a subset were weighed before being released. Water quality and habitat data were collected and recorded at each site and included Secchi disk measurement, dissolved oxygen, water conductivity, surface water velocity, water temperature, water depth, and substrate type.

Results and Discussion:

1.

1.1. MDC: None

1.2. AGFC staff captured and removed a total of 5,178 invasive carp weighing 85,488.8 pounds. Silver carp comprised 92% (4753), bighead carp 4% (192), grass carp 4% (230) and black carp .05% (3) of the total ([Table 1](#)).

Crews netted a total of 116 days during 2022. However, only one boat crew worked during part of June and September, and all of October, November, and December. Staff turnover was the contributing factor. Keeping a full five-person crew for removal efforts presented significant challenges. The program lost three crew members to full-time positions with the AGFC, one took a full-time job in the private sector, and another left due to health reasons. Two complete boat crews were available for only seven months during 2022.

There were a lot of negative environmental conditions, which affected removal efforts during. The White River, which has the highest abundance of invasive carp, was above flood stage for 6 ½ months and the Arkansas River had dangerously high flow rates for 3

months. When river levels exceed their banks, invasive carp move out into flooded timber and agriculture fields, which makes locating large schools in areas that can be fished with gill nets very difficult. This is particularly the case for the White River and its oxbow lakes. In addition, removal of invasive carp from the Arkansas River becomes more difficult due to floating debris and current.

The Invasive Carp Biologist worked with the AGFC GIS Division to develop a database to store all data collected during the programs invasive carp removal efforts. A dashboard is also being developed, which is dynamically tied to the database. The dashboard will provide maps showing the geographic distribution of the program's removal efforts, as well as descriptive statistical outputs and data export options. Development of these tools will help the program evaluate gear and method used as well as identify locations where more intensive removal efforts are needed and most productive.

1.3. MDWFP continued the carp processor reimbursement program which began in March 2021 after we failed to get commercial fishers who were willing to work under contract to harvest invasive carp. Purchase reimbursement contracts were renewed for October 2021 – June 2022 with two firms. They did not purchase any fish from October 2021 until May 2022. The firms purchased a total of 24,986 pounds of invasive carp during 2022. Silver carp comprised 97% (24,292 lbs.), bighead carp 1.5% (384 lbs.), and grass carp 1.5% (310 lbs.) of the total poundage. Another fish purchase contract was executed with one firm in October 2022, but they failed to purchase any fish in 2022. Contracts with two more firms were signed in January 2023. The total amount of invasive carp purchased in 2021 and 2022 is shown in [Table 2](#). An additional 15,009 pounds of invasive carp (13,909 lbs. Silver Carp, 900 lbs. Bighead Carp and 200 pounds of Grass Carp) not shown in Table 6 were purchased by one firm outside of their contract period so they were not reimbursed for these purchases.

In August of 2022, MDWFP began advertising to hire two temporary employees to harvest invasive carp from the project area. This is an effort similar to what the AGFC has done. In 2022 we were not able to find two qualified job applicants and we have submitted a no cost grant extension amendment to the USFWS to extend the time period on this grant.

2. TWRA staff conducted 32 gill net nights (719.9 hours) resulting in the collection of 83 silver carp and 9 bighead carp in Reelfoot Lake. Gill netting hours remained similar in Reelfoot Lake between 2021 and 2022, but number of silver carp and bighead carp captured increased in 2022 when compared to 2021 ([Table 3](#) & [Table 4](#)). Catch per unit effort (CPUE), reported as number of silver carp per net, was higher in the fall sample in both 2021

and 2022 and increased in the fall 2022 sample. Average CPUE increased from 1.67 in 2021 to 2.59 in 2022 while mean total length of silver carp remained similar. Most silver carp were captured in 4-inch mesh on Reelfoot Lake representing 66% of the total catch, followed by 5-inch mesh representing 27% of the total catch and 3-inch mesh representing 7% of the total catch ([Table 5](#)). Like 2021, carp remained relatively large compared to what is typically encountered in other Tennessee systems populated by silver carp (e.g., Kentucky and Barkley lakes). The good condition of carp in the existing population suggests that there is no shortage of food resources, and that densities are below any threshold that would cause negative density-dependent impacts on growth or condition.

During fall 2022, 56 silver carp were collected from Reelfoot Lake for age determination. The silver carp population in Reelfoot Lake was dominated by seven-year-old fish, with silver carp ages ranging from 4 to 13 years ([Figure 1](#)). Length-at-age analyses exhibited high stochasticity in length for all age classes within Reelfoot Lake ([Figure 2](#)). High stochasticity in length-at-age was expected in Reelfoot Lake due to the ability of silver carp to cross the spillway and access the lake from the Mississippi River. Reelfoot Lake had the highest range of ages when compared to all other waterbodies in West Tennessee.

3. MDC staff collected a total of 1,453 fish which included 38 unique fish species ([Table 6](#)) from 15 sites on the Mississippi River ([Figure 3](#)). Two silver carp were collected but no bighead carp, grass carp, or black carp were collected. Missouri Species of Conservation Concern encountered include American eel, river darter, skipjack herring and one Ohio shrimp.

Tables and Figures:

1.

1.1. MDC: None

1.2. AGFC:

Table 1. *Monthly results of the Arkansas Invasive Carp Removal Program during 2022. Results include effort (Days Worked), total number removed (Removed) and total weight (Weight) in pounds of silver, bighead, grass, and black carp harvested from the lower White River and lower Arkansas River and their tributaries and oxbows. [Return to Text](#)*

Month	Days Worked	Silver Carp Removed	Silver Carp Weight	Bighead Carp Removed	Bighead Carp Weight	Grass Carp Removed	Grass Carp Weight	Black Carp Removed	Black Carp Weight
Jan	11	102	1603.8	9	180	73	1693.6	0	0
Feb	11	510	7209.9	16	320	65	1508	0	0
Mar	6	119	2010	3	65	10	232	0	0
Apr	12	139	2282	5	125	54	1252.8	1	15
May	5	13	203.7	3	62.2	9	163.7	0	0
Jun	6	211	3055.2	20	351.4	1	19.6	2	54.9
Jul	11	558	8236.1	64	1244.3	2	48.8	0	0
Aug	15	510	8109.9	37	848.9	6	135.2	0	0
Sep	6	218	3585.9	1	21.2	0	0	0	0
Oct	15	1315	20525.3	23	501.6	6	151.2	0	0
Nov	11	476	8600.9	4	89.3	0	0	0	0
Dec	7	582	10736.5	7	156.6	4	89.3	0	0
Totals	116	4753	76159.2	192	3965.5	230	5294.2	3	69.9

1.3. MDWFP:

Table 2. Pounds of invasive carp purchased by Mississippi carp harvesting firms in calendar years 2021, 2022, and 2021/2022 combined. [Return to Text](#)

2021	Sliver Carp	Bighead Carp	Grass Carp	Total
Pounds	73,750	5,171	1,663	80,584
Percent by weight	91.52%	6.42%	2.06%	100%
Amount Paid by Processor	\$18,437.50	\$1,292.75	\$415.75	\$20,146.00
Grant Funds Expended	\$13,275.00	\$930.78	\$299.34	\$14,505.12
2022	Sliver Carp	Bighead Carp	Grass Carp	Total
Pounds	24,292	384	310	24,986
Percent by weight	97.22%	1.54%	1.27%	100%
Amount Paid by Processor	\$6,073.00	\$96.00	\$77.50	\$6,246.50
Grant Funds Expended	\$4,372.56	\$69.12	\$55.80	\$4,497.48
2021/2022	Sliver Carp	Bighead Carp	Grass Carp	Total
Pounds	98,042	5,555	1,973	105,570
Percent by weight	92.87%	5.26%	1.87%	100%
Amount Paid by Processor	\$24,510.50	\$1,388.75	\$493.25	\$26,392.50
Grant Funds Expended	\$17,647.56	\$999.90	\$355.14	\$19,002.60

2. TWRA:

Table 3. *Summary of gill netting effort (hours) and invasive carp demographics for Reelfoot Lake (SE = standard error, SD = standard deviation).* [Return to Text](#)

Reelfoot Lake		
Year	2021	2022
Net Hours	716.6	719.9
Invasive Carp Collected (No.)		
Silver Carp	54	81
Grass Carp	1	0
Bighead Carp	1	9
Black Carp	0	0
Silver Carp Captured (No./Size Class)		
< 250mm	0	0
251mm-475mm	0	0
476mm-650mm	1	0
≥ 651mm	53	81

Table 4. Summary of gill netting efforts (sets) and silver carp demographics for Reelfoot Lake in 2021 and 2022. Effort is separated between summer and fall sampling events. (SE = standard error, SD = standard deviation). [Return to Text](#)

Reelfoot Lake		
2021		
Months	Aug	Nov
Net Sets	16	16
Silver Carp Captured	25	29
Silver carp/net (SE)	1.56 (0.29)	1.81 (0.29)
Mean TL (SD)	851 (± 102)	918 (± 64)
Length Range	535-1001	781-1005
2022		
Months	June	Sept
Net Sets	16	16
Silver Carp Captured	14	69
Silver carp/net (SE)	0.86 (0.35)	4.31 (0.45)
Mean TL (SD)	866 (± 83)	834 (± 71)
Length Range	726-1032	665-965

Table 5. Summary of silver carp catch and size demographics by mesh size in Reelfoot Lake in 2022 (SE = standard error, SD = standard deviation). [Return to Text](#)

Reelfoot Lake			
Mesh Size (inch)	3	4	5
Silver Carp Captured	6	55	17
Silver Carp/mesh size (SE)	0.38 (0.21)	3.44 (0.94)	1.37 (0.41)
Mean TL (SD)	761 (64)	827 (62)	924 (44)
Length Range (mm)	719-870	665-994	859-1032

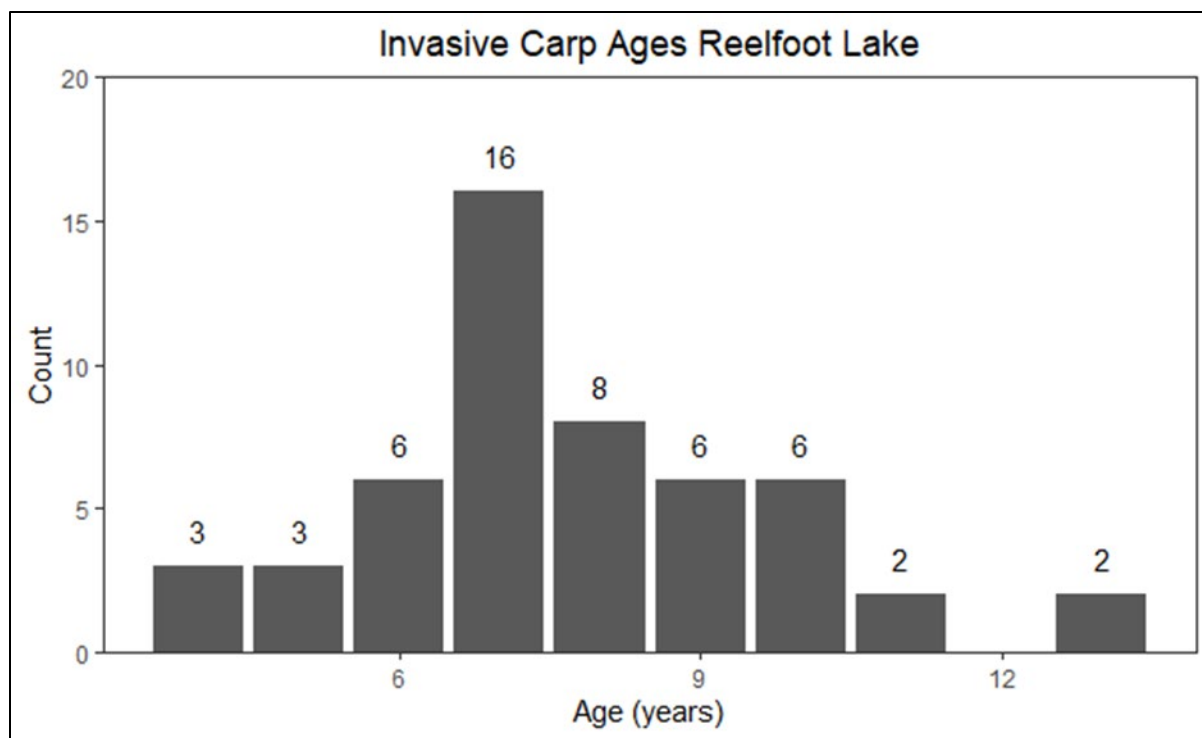


Figure 1. Histogram of silver carp age classes in Reelfoot Lake 2022. [Return to Text](#)

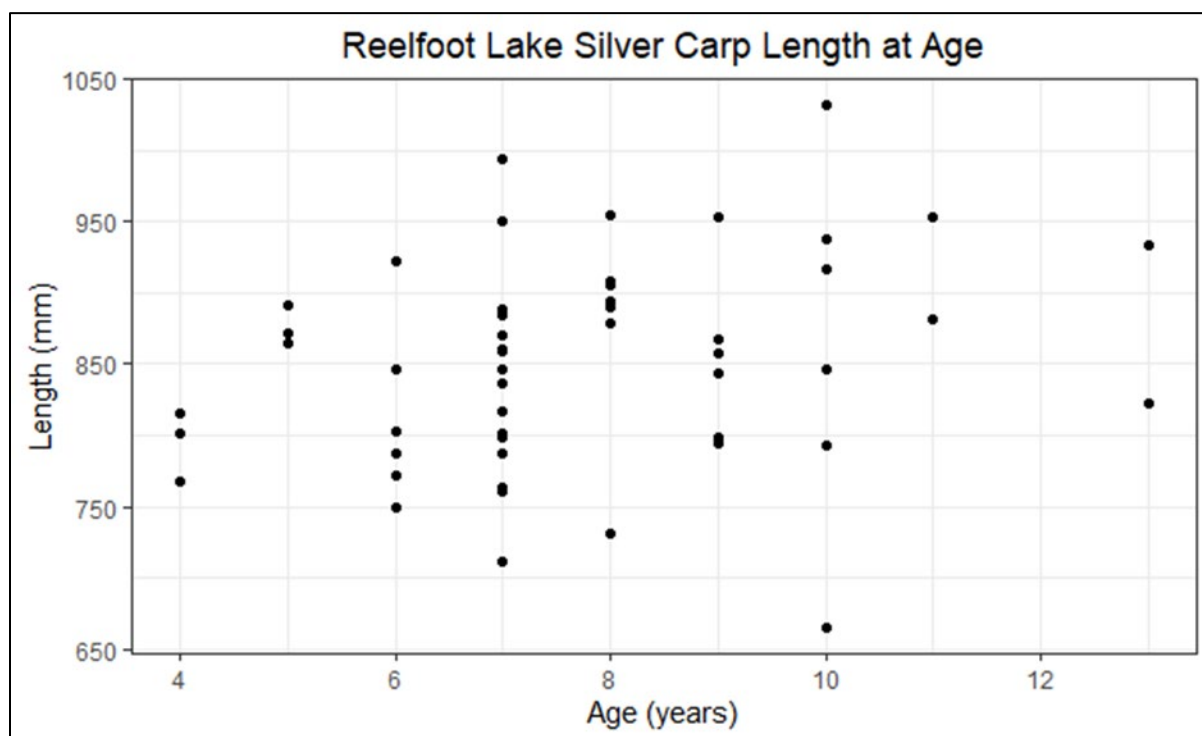


Figure 2. Length-at-age scatterplot for silver carp from fall 2022 gill netting in Reelfoot Lake. [Return to Text](#)

3. MDC:

Table 6. *Number of fish caught by species during fish assemblage sampling on the Mississippi River – fall 2022.* [Return to Text](#)

Common Name	Count	Common Name	Count
American Eel	1	Orangespotted Sunfish	15
Bullhead Minnow	13	Red Shiner	12
Black Buffalo	7	River Darter	1
Blue Catfish	16	River Carpsucker	12
Bluegill	16	River Shiner	29
Bigmouth Buffalo	3	Striped Bass	1
Blacktail Shiner	78	Sauger	2
Blue Sucker	7	Skipjack Herring	4
Common Carp	23	Speckled Chub	1
Channel Catfish	21	Smallmouth Buffalo	25
Channel Shiner	142	Smallmouth Bass	4
Emerald Shiner	528	Shortnose Gar	29
Flathead Catfish	2	Spotted Bass	9
Freshwater Drum	98	Silver Carp	2
Green Sunfish	6	Threadfin Shad	45
Gizzard Shad	233	Warmouth	1
Longear Sunfish	14	White Bass	32
Largemouth Bass	1	Yellow Bass	2
Longnose Gar	14		
Mooneye	3	Total	1,453



Figure 3. *Locations of fish assemblage sampling sites on the Mississippi River.* [Return to Text](#)

Recommendations:

1.
 - 1.1. MDC: Implement invasive carp removal efforts on the Mississippi River during 2023.
 - 1.2. AGFC: Start using data collected to improve/increase capture of invasive carp. Continue to identify and test new gear and techniques to improve efficiency of removal efforts.
 - 1.3. MDWFP: None
2. TWRA: Standardization of aging techniques and further evaluation of length-at-age data would be beneficial. Although we have been unsuccessful at establishing/incorporating large-scale removal efforts thus far, we will continue to pursue the use of this management tool.
3. MDC: Fish assemblage sampling should continue in the future to build a long-term dataset.

References:

Ratcliff, E. N., E. J. Gittinger, T. M. O'Hara, and B. S. Ickes. 2014. Long Term Resource Monitoring Program Procedures: Fish Monitoring, 2nd edition. A Program Report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program. June 2014. Program Report LTRMP 2014-P001. 88 pp. including Appendixes A–G.